

IV. *Some Observations on the Excrement of Insects ; in a Letter addressed to William Spence, Esq., F.R.S., &c. By JOHN DAVY, M.D., F.R.S., Inspector-General of Army Hospitals.*

[Read January 2nd, 1854.]

MY DEAR SIR,

THE excrement of insects has not, I believe, had that attention paid to it, chemically, which the subject deserves ; especially taking into account the vast number of insect-species, how they abound, the manner in which they are diffused, or the part, as a class, which they appear to perform in the economy of nature. This too being your opinion as expressed in a letter with which you have favoured me, I am induced to collect and submit to you such results as I have obtained in a limited number of trials, with the request that you will communicate them to the Entomological Society, should they appear to be of sufficient interest to have the attention of that learned body.

The inquiry I commenced when I was in the West Indies, between 1846 and 1849, and have since continued from time to time as opportunities have offered.

I shall first bring under notice the results of the experiments made on the excrement of insects in their first stage of development, that of the larva or caterpillar. Even at the risk of being tedious, for the sake of accuracy, I must be more particular than I could otherwise wish, and shall have to describe individual instances. I have to express regret at the same time for my inability, without aid in those distant colonies, to give the specific names of the specimens which yielded the excrementitious matter examined.

1. The caterpillar of a butterfly, resembling *Papilio Aphrodite*, Linn., common in Barbados, in December, voided excrement in abundance when actively feeding, in the form of little green pellets. A certain quantity of these, dried and acted on by proof spirit, yielded a residue on evaporation, in which hippuric acid, or a matter having similar properties, was detected ; thus, to mention one, with muriatic acid, on slow evaporation, it afforded prismatic crystals, shooting from a centre, and which did not deliquesce in a moist atmosphere.

2. A large caterpillar of a moth, resembling *Sphinx Atropos* when voraciously feeding, voided much excrement in the form of

cylindrical masses of a dark olive green, some of which were partially covered with a yellowish crust. The matter of this incrustation was found to be chiefly lithate of ammonia. Under the microscope it was seen to consist of spherical granules, most of them about  $\frac{1}{10000}$  of an inch in diameter; these were dissolved immediately in dilute nitric acid, and when heated (a drop of the solution being placed on a slip of thin glass), acquired the rich purple hue characteristic of lithic acid under this treatment.

3. A large caterpillar of a *Sphinx*, after it had ceased feeding, about to assume the chrysalis state, put under a glass cover, in less than twenty-four hours parted with its enveloping integuments, and became completely incased; in doing so, it voided a good deal of brownish fluid. This, tested for lithic and hippuric acid, afforded no traces of the former, but pretty distinct ones of the latter.

4. Another large caterpillar of a *Sphinx*, in a state very similar to that of the preceding, was very restless in confinement, and shortly voided some dark fluid excrement, which, on examination, gave results like those last mentioned.

This caterpillar was killed by immersion in spirits of wine. Opened, its stomach was found to be the most conspicuous organ; it extended nearly the whole length of the abdominal cavity, and was distended with a dark, mucous fluid. Under the microscope a tubular structure was seen contiguous to it, and connected with it. Conjecturing that these tubes might be renal ones, the part was taken out, and digested in water, to which a little nitric acid had been added: the solution formed was found to contain lithic acid; thus a drop of it evaporated, and heated on a support of thin glass, acquired the rich purple tint distinctive of this acid.

5. A large caterpillar of another species of *Sphinx*, taken from the leaves of the sweet potatoe on which it was feeding voraciously (in confinement still feeding), voided a great deal of almost black excrement, in cylindrical masses, rounded at their ends. On none of them was there any appearance of incrusting matter, as in the instance No. 2. They yielded a brownish solution to proof spirit; and this evaporated, afforded an extract, which, with nitric and muriatic acid, afforded crystals, some of them of the form of hippuric acid similarly combined.

6. A silk worm actively feeding on mulberry leaves voided excrement in the form of small black pellets: on one of them there was a brown incrustation; this, agitated with a drop of water, rendered the water slightly turbid. Under the microscope it exhibited granules; these were soluble in dilute nitric acid, and afforded,

when evaporated and heated, a slight but distinct trace, in the color produced, of lithic acid.

These few are all the trials I have to notice on the excrements of larvæ. With the exception of the last, in this country, they were all made in Barbados.

The next I have to mention were on the excrement of the perfect insect, immediately after quitting its puparium; these likewise were made in Barbados.

7. The pupa of the caterpillar; number 1, I may premise, occurs attached by a fine, short thread and hanging perpendicularly. Before the escape of the imago the color of the chrysalis changes from apple green to a dull blue, passing into brown; becoming when empty of a light grey. On quitting its case the butterfly adheres to it, its head upwards, its wings hanging down. Thus it remains motionless, with the exception of occasionally expanding its wings, till the intestine has been unloaded, fitting it for flight, secure from its position of not being soiled in the slightest degree by what it voids. The discharged matter I have found to vary in different instances, and this at the same season, and when voided by individuals similarly reared, and detached from the same shrub. The excrement of one was a turbid liquid of a purplish hue, as if tinged by the purpurate of ammonia. Under the microscope, there were to be seen purple patches, some colorless rhomboidal plates, as if of lithic acid, and numerous granules, as of lithate of ammonia. By the test of nitric acid and heat, manifest proof was obtained of the presence of lithic acid, a strong purple color being produced. The excrement of another was of a brownish hue, and turbid. In it were detected traces of hippuric acid, of lithic acid, and of urea, judging from the form of the crystals obtained from an alcoholic solution, from the effect of nitric acid, and of that of this acid and of heat. The excrement of a third, also a brownish fluid, appeared to contain little else than hippuric acid, with perhaps a trace of urea. The extract obtained from the alcoholic solution of the dried matter emitted, on the addition of nitric acid, an odour like that of the urine of the horse, and afforded crystals on evaporation similar to those from the same urine when treated in like manner.

8. A *Sphinx* from the larva number 4, on quitting its puparium voided a considerable quantity of brownish turbid fluid. This excrement afforded distinct traces of lithic acid in the form of lithate of ammonia, and also of hippuric acid; the former in suspended granules, the latter in solution. The lithic acid was indicated by the effect of nitric acid and heat; the hippuric acid

by the crystals obtained on evaporation after the addition of muriatic acid. On this addition being made, a smell was perceived like that from the urine of the horse. The *Sphinx* shortly after, and before it had taken any food, was killed and examined; its stomach and intestine were found empty.

9. A *Sphinx* from larva, No. 3, less than a month in undergoing its metamorphosis, voided, on leaving its puparium, a good deal of turbid, reddish-brown fluid, which, subjected to examination, was found to contain lithate of ammonia, a trace of the purpurate of ammonia and of hippuric acid. Under gentle pressure, when laid hold of, this *Sphinx* discharged pretty much semifluid matter of a brick red color, which, under the microscope, was found to be composed of spherical granules, varying in diameter from  $\frac{1}{120000}$  to  $\frac{1}{150000}$  of an inch. After standing a little while many of them coalesced and formed larger granules. Tested by nitric acid and a regulated heat, they had the character of lithate of ammonia. I may mention further, that in the forsaken puparium there was a good deal of whitish matter; this washed out with water and collected, under the microscope was seen to consist of granules of about  $\frac{1}{100000}$  of an inch in diameter; and tested, was found likewise to be of lithate of ammonia. The quantity of excrement accumulated in this moth during its change of state, and voided on acquiring its perfect form, was truly surprising, and not less so the abundance in it of lithate of ammonia.

I shall now pass to the results obtained from insects caught, and consequently of uncertain age in relation to their last birth or time of quitting their puparia.

10. A *Sphinx*, after about twenty-four hours' confinement, under glass, with a free supply of air, died without yielding any excrement. On opening it the lower portion of its intestine was found distended with a brownish opaque fluid. The opaque matter, it may be inferred, was lithate of ammonia; for under the microscope it exhibited the finely granular condition of this compound, and when acted on by dilute nitric acid and heat, was first dissolved, and then acquired the rich purple color distinctive of lithic acid.

On examining the abdomen, opening the *Sphinx* under water, some minute cells, with delicate tubes proceeding from them—part I believe of the renal apparatus—were observable by means of the microscope; they contained an opaque matter, probably lithate of ammonia, for, tested for lithic acid, proof was obtained of its presence.

Whilst in Barbados other large moths of the *Sphinx* tribe were

caught and placed in confinement; I have notes of six. From all of them either excrement was voided during life, or was found in the intestine on examination after death, and of a nature similar to that last mentioned, composed chiefly of lithate of ammonia. No other solid substance, no crystals were observable when submitted to the microscope. In one, as in the instance last described, on opening the abdomen some delicate tubes were seen ramifying on the intestine externally. These too contained an opaque whitish matter, which, from the effect of nitric acid and heat, appeared to be lithic acid; but, more probably, was lithate of ammonia.

11. A yellow butterfly, in confinement, voided a little semifluid brownish excrement. Seen under the microscope, diluted with water, it exhibited many well formed rhomboidal plates, or low prisms, as if of lithic acid, with which were intermixed minute granules, as of lithate of ammonia. Acted on by nitric acid and heat the purple tint was produced indicative of lithic acid.

12. A black beetle, with suckers or cushions to its feet and claws, voided a considerable quantity of fawn-colored matter, in little grains about the size of mustard-seed. By the same test as the preceding they were found to consist chiefly of lithate of ammonia. No appearance of crystals was seen under the microscope.

13. A *Mantis* (*M. bicornis*, Linn.), in confinement, yielded a minute portion of excrement. This, mixed with a little water on a glass support, exhibited under the microscope a few minute rhomboidal crystals, and, acted on by nitric acid and heat, acquired a pink tinge, denoting the presence of a little lithic acid.

14. A fire-beetle (*Lampyrus ignita*, Linn.) voided, in confinement, a little brownish excrement. It appeared under the microscope to consist chiefly of epithelium-scales and of granules; the latter, of lithate of ammonia, being dissolved instantly by dilute nitric acid, and acquiring when heated the color marking lithic acid.

15. A light yellow moth, during the night, in confinement, voided a large quantity of excrement, that is, large in proportion to the small size of the insect: it was white and semifluid. Under the microscope it was found to abound in granules of about  $\frac{1}{3000}$  of an inch in diameter; they were completely dissolved by dilute nitric acid, and afforded on evaporation when heated the rich purple hue distinctive of lithic acid.

16. A brown moth, with white spots, weighing 1.6 grain, voided

a good deal of excrement in confinement, some portions of which were whitish, some reddish. In the former, under the microscope, a few crystals were seen, as of lithic acid, and numerous granules, about  $\frac{1}{3000}$  of an inch in diameter, as if of lithate of ammonia. The latter contained no crystals, only granules. Heated with nitric acid, lithic acid was strongly indicated in both.

17. A brown moth, of a lighter color than the preceding, of about the same size, voided a pretty copious fawn-colored excrement, which, mixed with water, under the microscope exhibited aggregated masses as if formed of granules, and some crystals, square plates, and one low four-sided prism. The granulated masses and crystals dissolved in nitric acid, and the rich color, the mark of lithic acid, was produced by exposure to a regulated heat.

18. A dark brown moth, of medium size, in confinement during twenty-four hours, voided a good deal of reddish excrement, partly in minute granules, and partly in little masses, probably aggregates of the granules; such they appeared under the microscope. No crystals were seen. By the nitric acid and heat test, lithic acid was found to abound. Twenty-four hours longer in confinement this moth was found dead, after having voided a good deal more of red excrement, like the preceding, excepting that in one small portion of it crystals of lithic acid (hexagonal and quadrangular plates) were observable. The nitric acid test gave the same result as the last.

19. A small white moth, that died after being confined twenty-four hours, voided a pretty considerable quantity of semifluid, almost colorless excrement, composed chiefly of granules, which, from the action of nitric acid, it may be inferred were of lithate of ammonia.

20. A small grey moth voided a minute portion of brownish excrement, consisting, as seen under the microscope, of little granular masses, and dispersed granules without crystals: from the effect of nitric acid and heat it would appear that they were composed principally of lithate of ammonia.

21. A brown moth, about half an inch in length, in confinement, before it died voided a portion of excrement so minute in quantity that it was not easy to collect; notwithstanding, it afforded satisfactory proof of the presence of lithic acid by the nitric acid test. The rich distinctive hue was visible to the naked eye, and well shown under the microscope.

22. A delicate white moth, with a tufted tail, deposited in con-

finement three portions of semifluid excrement, each similar, composed chiefly of granules of about  $\frac{1}{3000}$  of an inch in diameter, which, by the test of nitric acid, appeared to be of lithate of ammonia.

23. A large butterfly supplied with syrup, which it sucked up greedily, voided a drop of fluid excrement of a light brownish hue. This collected with care, after having been diluted with water to increase its bulk, was allowed to evaporate spontaneously on a glass support. Thus prepared, seen under the microscope, it exhibited in a transparent medium some minute plates and fine granules. A very little dilute nitric acid was added; on its evaporation stellaform groups of crystals appeared, reminding of nitrate of urea, and there was a urinous smell, not unlike that from human urine with nitric acid. Heated carefully the purple hue indicative of lithic acid appeared in specks fading from them as centres.

24. A black beetle common in Barbados, about half an inch in length, of impetuous flight, striking against objects, when it enters a room at night, with a force, considering its size, almost incredible, in confinement voided a large quantity of very light fawn-colored excrement, in a semifluid state. It was composed of spherical particles from  $\frac{1}{6000}$  to  $\frac{1}{8000}$  of an inch in diameter, as seen under the microscope, without crystals or any other form of matter. Tested, it was found to contain lithic acid, and, it may be concluded, in combination, as lithate of ammonia, for it dissolved more readily in hot than in cold water, the hot solution in cooling becoming slightly turbid, and the extract obtained on evaporation, after filtration, acquiring when heated with nitric acid the characteristic color due to lithic acid.

25. A brown grasshopper, found amongst Guinea-grass, in confinement, voided two kinds of excrement: one, it may be inferred, faecal, in small cylindrical masses, almost black; the other urinary, at least in part, of the same form, of a light fawn-color. These, the latter, dissolved without effervescence in dilute nitric acid, and acquired, when the solution was evaporated and subjected to a regulated heat, the color denoting lithic acid.

26. A field-cricket, in confinement, voided some excrement in small black pellets, in which no lithic acid could be detected, and which was probably altogether faecal. Bread was given, which it ate freely. During the following twenty-four hours it voided more excrement: some, like the preceding, black; some in oval pellets, smeared with a semifluid matter, brown and with a urinous odour. These, broken up and diluted with water, ex-

hibited, under the microscope, spherical granules, as of lithate of ammonia, globules like those of starch, and which were colored blue by tincture of iodine, and irregular fragments as of vegetable matter. The presence of lithic acid was detected by the usual test. It was tested for urea; but the presence of this substance was not demonstrated, which may have been owing to the smallness of the quantity subjected to experiment.

27. A cock-roach just killed, taken from the apothecary's store room, was found, on being opened, to have its stomach and intestine distended with small dark fragments, amongst which were some possessing the color and lustre of Spanish flies. A system of tubes, containing a white opaque matter, was seen on each side, and at right angles to the intestine. This matter examined was found to contain lithic acid, and was probably in combination with ammonia.

28. A large dragon-fly, in confinement, voided pretty much reddish excrement, which, under the microscope, appeared in little aggregate masses, with (when broken down and diffused in water) some very thin colorless and transparent hexagonal plates. It dissolved in part in nitric acid, and heated acquired a rich purple color.

29. Another dragon-fly, a smaller species, voided in confinement several small cylindrical masses, in part brick-red, and in part blackish. Broken and mixed with water, under the microscope they appeared to be composed of the *debris* of insects, portions of wings, legs, &c., and of granules. Acted on by dilute nitric acid, a partial solution was immediately effected, in which lithic acid was clearly detected by the ordinary test.

30. A large *Mantis* (*M. Siccifolia?* Linn.), in confinement, voided a good deal of excrement in small pellets, some blackish, some brown. The latter, under the microscope, after admixture with water, showed numerous granules larger than those of lithate of ammonia commonly are, being about  $\frac{1}{2000}$  of an inch in diameter, yet having the properties of this compound, as tested in the ordinary way.

31. A large humble-bee, its prevailing color black, in confinement voided pretty much excrement in a semifluid state. Under the microscope it appeared to consist chiefly of corpuscles, reminding one of the pollen of flowers. Acted on by dilute nitric acid and heat, the presence of a little lithic acid was demonstrated.

32. Several wasps, together with their comb, placed under a glass shade, were found dead on the fourth day of their confine-



ment, after having voided some excrement, in which lithic acid was detected by the ordinary test. During the first two or three days it was remarked that they fed on their comb.

The cells of the comb contained larvæ nearly in a state to pass into the perfect form. One taken out and killed was examined. Its intestine, the lower portion, was found full of a chalk-like matter, which on examination proved to be lithate of ammonia.

The comb, freed from the old wasps, was placed on a clean plate and covered with a glass shade. In a few hours a young wasp made its appearance, having broken down the lateral portion of its cell. It soon voided some excrement, which was of two kinds, one almost black, of an offensive smell, a kind of meconium; the other of a light fawn color. This, the latter, had what appeared mucous covering, within which was a fluid, and in that a little mass of soft consistence, about the size of a barleycorn. The fluid was brownish and transparent; with nitric acid it emitted a smell like that from impure urea or human urine similarly acted on. The included little mass was found to consist principally of lithate of ammonia.

33. Several flies, such as are common in Barbados within doors, somewhat smaller than the common English house-fly, voided in confinement a little semifluid excrement. By the ordinary means a distinct trace of lithic acid was detected in it. The liquid part afforded indications of urea, yielding a honey smell on the addition of nitric acid, and minute crystalline plates on evaporation in sunshine, which deliquesced in moist air.

34. Musquitos. These insects, averse to light, harbour in dark places; the case of my microscope was a favourite place of resort: its brass stand became spotted with their minute droppings, so minute, indeed, as hardly to be distinguishable without a magnifying glass. The specks were nearly of the same size and appearance, except that some were darker than others. A good many of each color were collected; heated apart with nitric acid, both proved rich in lithic acid, judging from the purple color produced.

A single musquitoe was confined under a wine glass, inverted on a porcelain plate. Shortly after, on careful examination with a magnifying glass, a speck of excrement was detected of a light color and semi-globular form, as if voided in a semifluid state. Removed carefully to a slip of thin glass, and nitric acid added, it dissolved completely, and cautiously evaporated and heated, a distinct mark of the presence of lithic acid was obtained; there was a circular patch of a bright rose-hue, which was dissolved by

water. A single musquitoe weighed was found equal to about  $\cdot 008$  of a grain. The balance used was a delicate one, of Robinson's construction.

35. A large fly (four white bars on its thorax, white spots on abdomen, yellow about the eyes), in confinement, voided some excrement, partly in small cylindrical masses of a fawn color, partly spread out and semifluid, of a light brownish hue. In the former, under the microscope, two forms of crystals were seen; one like those of lithic acid; the other like those of ammoniaco-magnesian phosphate. In the latter, granules only were seen. Both acted on by nitric acid and heat, afforded proof of the presence of lithic acid.

36. A mason-bee, in confinement, voided a very minute portion of excrement, semi-transparent, semifluid, and of a brownish hue. By the usual test, it was found to contain lithic acid.

37. An elegant beetle with cushioned feet, in confinement, voided several small pellets, some of them with a brownish incrustation. These, the incrustated ones, acted on by nitric acid and heat, afforded distinct traces of lithic acid. Examined under the microscope, they appeared to be composed principally of vegetable matter. In those without incrustation, and of a darker hue, no lithic acid could be detected; they were, probably, entirely faecal.

38. A brown speckled moth, its wings spotted white, in confinement voided a comparatively large quantity of brownish excrement of soft consistence. Under the microscope, fine granular matter—the granules about  $\frac{1}{3000}$  of an inch in diameter—were observable, and many crystals; of these, some were reddish brown, some colorless; some, the majority, were rhomboidal plates of moderate thickness; others nearly cubical; one plate, a colorless one, was hexagonal. They varied in size; they were large microscopical objects as seen with an  $\frac{1}{8}$ th inch glass. A drop of nitric acid added, the granules were instantly dissolved, the crystals slowly. The solution evaporated and heated, acquired a rich purple hue. The granules, it may be inferred, were of lithate of ammonia; the crystals, probably, in most part, of lithic acid.

All these observations on perfect insects, with one exception, were made in Barbados; the single exception was that on the fire beetle, which was made in Trinidad. The observations which I am now about to offer were made in this country, and the greater number of them in the neighbourhood of Ambleside. In recording these latter results, I have had the advantage in most instances of being able to assign correct names to the insects, their

species having been determined by Francis Walker, Esq., and by J. W. Douglas, Esq., who, at your request, were so obliging as to examine them.

39. A butterfly (*Vanessa Urticæ*), on pressure being applied to its abdomen when in a torpid state (it had been caught on the wing), a comparatively large quantity of semifluid excrement was ejected, of a rose color, as if from the presence of rosacic acid. Under the microscope it was seen to be very uniformly composed of spherical granules, of about  $\frac{1}{10000}$  of an inch in diameter. It dissolved immediately in nitric acid, and when evaporated and heated, acquired the rich purple hue indicative of lithic acid, or of lithate of ammonia.

40. Another butterfly, of the same kind, voided in confinement a small quantity of reddish excrement; in which, besides granules, as of lithate of ammonia, rhomboidal plates, more or less truncated at their angles, probably of lithic acid, were seen under the microscope. The granules dissolved rapidly in dilute nitric acid; the crystals slowly. The whole when evaporated and heated acquired the color indicative of lithic acid.

41. A *Vanessa Io*, in confinement, voided some greyish excrement, which under the microscope, and the action of nitric acid and heat, was found similar to the first of the two preceding instances.

42. A moth (*Smerinthus Populi*), in confinement, voided pretty much reddish excrement, which was found to consist principally of lithate of ammonia.

43. Another moth (*Crambus culmellus*), pressure being applied to its abdomen, a minute quantity of light colored excrement was discharged, which, on examination, proved similar to that last mentioned.

44. A moth (*Triphæna pronuba*), in confinement, voided a good deal of fawn-colored excrement. Under the microscope, it exhibited spherical granules, as of lithate of ammonia, with which were intermixed low four-sided prisms or cubes of a pretty large size. Acted on by nitric acid and heat, the rich purple, marking lithic acid, was produced.

45. Another moth of the same kind as the last, in confinement, during one night voided excrement in three separate portions; one reddish, one brown, one of a fawn color. They were found to consist principally of lithate of ammonia. On pressing the abdomen of this moth, a reddish brown fluid was obtained, which had the smell of human urine, and which was changed to a honey smell on the addition of a little nitric acid. On slow evaporation

the solution yielded crystalline forms, rhomboidal plates, resembling those of nitrate of urea.

46. A moth (*Cerapteryx graminis*) voided no excrement in confinement. After its death, the anal portion of its abdomen was detached and digested for a few minutes in dilute nitric acid; the solution, evaporated and exposed to a graduated heat, afforded a faint but clear trace of lithic acid.

47. A fly (*Anthomyia platura*), in confinement, voided a minute portion of excrement; which, on examination, was found to consist principally of lithate of ammonia.

48. Another fly (*Calliphora vomitoria*), in confinement, voided a very little excrement, which was ascertained to be like the last.

49. A butterfly (*Pontia Napi*) yielded in confinement some excrement; found to consist chiefly of lithate of ammonia.

50. Two cow-dung flies (*Scataphaga stercoraria*), in confinement, voided a little excrement in reddish patches, which, under the microscope, exhibited the usual granular appearance of lithate of ammonia, the granules about  $\frac{1}{100000}$  of an inch in diameter, and was similarly acted on by nitric acid and heat.

51. Several small flies (*Musca rudis*), in confinement two or three days, voided pretty much greyish excrement deposited in patches. Under the microscope, after being diluted with water, it exhibited, in addition to granules, some prismatic slender crystals, as of phosphate of lime, and some scales, as of epithelium. Acted on by nitric acid and heat, proof was obtained of the presence of lithic acid.

52. A honey bee (*Apis mellifica*) died in confinement without voiding any excrement. On pressing its abdomen a colorless drop of fluid was obtained, in which a trace of lithic acid was detected.

53. Three bees, taken from their hive in October, presently died at a temperature of about 40° Fahrenheit. The anal portion of the abdomen of each was separated and digested in dilute nitric acid; on evaporating the solution at a graduated heat, a trace of lithic acid was detected.

54. A wasp—the common English wasp—which in confinement voided no excrement, yielded after death, the abdomen being pressed, a drop of fluid, in which, under the microscope, a few granules were seen, as of lithate of ammonia, and in which a trace of lithic acid was found by the ordinary means.

55. A beetle (*Geotrupes sylvaticus*), in confinement, during one night voided many small cylindrical masses of a brown color, with

a sprinkling of a matter on their surface of a lighter hue. One broken up, mixed with water, under the microscope exhibited minute granules, as of lithate of ammonia, particles of an irregular form, as of earthy matter, a few forms as of infusoria, and fibres, &c., as of vegetable matter. The pellets, digested in dilute nitric acid, separated into smaller ones, seeming to show casts of the intestines. The solution (the greater portion of the excrement remaining undissolved), evaporated and heated, afforded proof of the presence of lithic acid.

After having been killed by the vapor of camphor, an opaque filament was seen adhering to its anal extremity. This, digested in water and slightly agitated, under the microscope exhibited granules like those of lithate of ammonia, with a filamentous substance, probably mucus. The granules, about  $\frac{1}{10000}$  of an inch in diameter, were immediately dissolved in dilute nitric acid, and on the application of heat the purple hue was produced denoting lithic acid.

56. A beetle (*Geotrupes stercorarius*), in confinement, voided some excrement of a soft consistence, and nearly white, which was found to consist principally of lithate of ammonia. Killed by immersion in water, and opened, white vessels were seen on the intestine containing an opaque matter, which, tested by nitric acid and heat, proved to be lithic acid or lithate of ammonia.

57. A beetle (*Blaps mortisaga*), in confinement, voided some excrement in the form of pellets of a dark grey colour, partially covered with a crust of lighter hue. Broken up and mixed with water, under the microscope the prevailing color was light greenish, from vegetable matter in fragments, amongst which were interspersed many granules, as of lithate of ammonia. Digested for a short time in dilute nitric acid, and the solution evaporated and heated with care, proof, in the color produced, was obtained of the presence of lithic acid.

58. A female *Telephorus pilosus* voided in confinement a little excrement, which was found to consist principally of granular lithate of ammonia.

59. A male *Telephorus Melanurus* (?) taken in company with the preceding, and in the act of coitus, died in confinement without voiding any excrement. The anal extremity detached, acted on by nitric acid and heat, afforded a trace of lithic acid.

The trials on the four following insects were made about twelve months after their death, kept, put by in a drawer, without any care; they were some of those on which experiments had been tried to show the effects of different agents on insects, as described

in a letter which I had the honour to address to you in April, 1851, and which was published in the Transactions of the Entomological Society for the same year.

60. Of a *Musca lanio* the anal portion was cut off, and digested in dilute nitric acid; the solution formed, carefully heated gave a distinct trace of lithic acid in the color produced.

61. A *Musca domestica*, similarly treated, afforded a like result.

62. A *Musca stabulans*, the like.

63. A fly (*Heteromyza buccata*) yielded a very slight trace of lithic acid, requiring microscopic examination to distinguish the color.

64. An *Erystalis tenax* afforded a slight but yet a distinct trace of the acid.

On these, the preceding observations, having now described all I have to offer, I would beg to make a few remarks in conclusion.

Considering the properties of the excrementitious matter examined, I apprehend it may be admitted that in almost every instance a part of it, and in most instances the larger portion, was urinary,—a renal secretion.

Adopting this conclusion, the urine of the insects in their earlier stage, their larva state, would appear to differ considerably from that of the same insects in their imago or perfect form. Thus, whilst in the latter it was found to consist chiefly of lithate of ammonia, in the former lithate of ammonia was sparingly detected, or not at all; what seemed to be hippuric acid being more abundant. Should further inquiry be confirmatory of this, will not an interesting analogy be established, viz. of one, the perfect insects, in their urinary secretion, to birds, which they resemble in so many other particulars; of the other, the insects in their larva state, in relation to the same secretion, to the mammalia, to which also, especially in their mode of feeding, they bear a certain resemblance—a resemblance that may be traced through several orders, according to their diet? Even in their transition state, that is, when passing from the larva to the imago, comparing the pupa of the insect with the excluded ovum of the bird, the analogy seems to be sustained—both, in the process of hatching to evolve the perfect animal, being independent, with the exception of atmospheric air, of any external material supply. The renal secretion of the foetal bird is, I believe, always lithate of ammonia; at least, I am not aware that any other has yet been detected. In the insect we have seen how, when fully formed and quitting its puparium, the same compound has abounded.

The proportional quantity of the urinary secretion of birds, and the large quantity of lithate of ammonia which exists in it,—is indeed its principal part,\*—is remarkable ;—we have proof of it, whether we examine the excrement of any single bird, or direct our attention to the immense beds of guano, of which the urine of birds, variously changed, appears to be the chief ingredient. Nor is the urine of insects in relation to quantity less remarkable. In examining it, I have often been surprised at its abundance. In my notes, when mentioning the excrement of the moth, No. 16, which weighed little more than a grain and a half, I find the remark, that its excrement exceeded in quantity—it was similar in kind—that of a humming-bird which I was examining at the time, and which weighed 92·5 grains. The musquitoe, and its urinary secretion, may be adduced as another illustration, as well as of the delicacy of the test employed to detect the organic acid. In your letter to me, that already referred to, adverting to the importance of insects in the economy of nature, after noticing their number, how probably 250,000 species may be estimated to exist, you specially point to one function of this great class,—the eating of plants and the converting them into animal matter fit for the food of birds, fishes, &c. Another part, in harmony with this, may be pointed out, viz. how by their excrement, especially the urinary portion of it, they contribute to manure and fertilize the earth for the production of plants, on which so many of them depend for a subsistence. We have seen in the examples last given—the four last—that the peculiar urinary secretion may be detected in the dead insect, after many months, in accordance with the character of lithate of ammonia. This quality of endurance, I need hardly remark, fits it admirably for a persistant manure.

I am,

My dear Sir,

Yours very truly,

JOHN DAVY.

Lesketh How, Ambleside,

Dec. 17, 1853.

\* Without any exception, I believe the urinous secretion of birds is principally lithate of ammonia. I have found it such in every instance that I have examined it, whatever the kind of food; in the instance of the graminivorous birds, such as the goose and the swan, the lithate incrusts the faecal excrement commonly much in the same manner as I have found it incrusting the same excrement from beetles.